

# HE-D<sub>3</sub> POLARIZATION OBSERVED IN PROMINENCES

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Abstract. Spectro-polarimetric measurements of the D<sub>3</sub>-He I 5876 Å line profile in 35 prominences have been performed in 2003 with the Gregory-Coudé Telescope in Locarno. Two different experimental techniques (ZIMPOL and Beam-exchange method) have been successfully employed to determine all four Stokes components. Both give compatible results. The preliminary results as well as the measurement techniques are reported.

## 1. Introduction

The understanding of the prominence formation is strongly connected with the knowledge of the magnetic fields which are responsible for their support. Polarimetric observations of the emission lines in prominences allow to study the structure and intensity of their magnetic fields through the Hanle and the Zeeman effect. After the extensive measurements of Leroy *et al.* (1984) and Athay *et al.* (1983), in the last two decades the observational activity in this domain was rather poor. On the other hand the progress in the instrumentation improved remarkably the polarimetric sensitivities that can now be achieved. Recently, new polarimetric observations of few prominences were reported (e.g. Paletou *et al.*, 2001; Wiehr and Bianda, 2003). In the present work we proceed to a more extended observational program.

## 2. Observations

The evacuated Gregory-Coudé telescope which is used at IRSOL (Istituto Ricerche Solari Locarno), has the advantage to introduce small instrumental polarization and cross-talks (Sanchez *et al.*, 1991). Both are generated mainly from two off-axis flat mirrors, whose effects theoretically cancel out around the equinox. Otherwise they increase almost linearly with declination and stay almost constant over one day of solar observations. At

solstice the total instrumental linear polarization reaches almost 3% and the circular polarization is smaller than 1%.

19 prominences were observed from 24th March to 24th April 2003 using the beam exchange technique proposed by Semel *et al.* (1993). This technique allows a measurement free from effects introduced by the detector gain table. The data reduction technique and the instrumental set-up are described by Bianda *et al.* (1998). For each prominence we took various sets of measurements at different locations and times. Each set included typically about 20 exposures of 5 seconds each on a fixed position on the prominences, from which all four Stokes components were extracted.

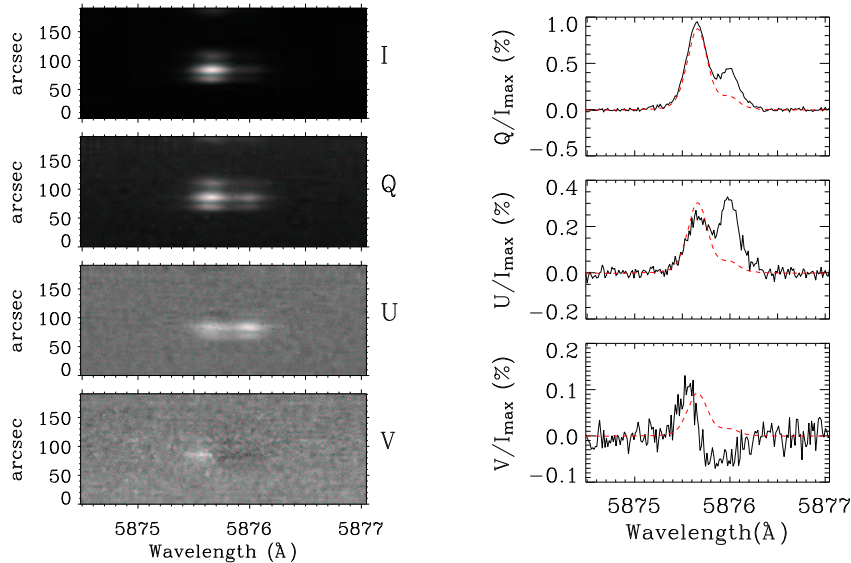
A second observation series was performed using the Zurich Imaging Polarimeter ZIMPOLII (Stenflo *et al.*, 1992; Povel, 1995; Gandorfer and Povel, 1997; Gandorfer, 1999), which allows to get polarization measurements free from seeing effects. 16 prominences were observed from 22nd May to 26th September 2003. The image was rotated with a Dove prism set after the analyzer in order to keep the limb parallel to the spectrograph slit. Various sets of measurements were taken at different locations. Each set included typically 100 images of 10 seconds exposure each.

In both observing techniques additional measurements were regularly performed for calibration purposes. The light originating at center of the solar disc was assumed to be unpolarized and therefore used as reference to establish the correction for the instrumental polarization. The background intensity profile was determined observing a quiet region of the halo near the prominence. We sometimes measured a nonzero polarization in the background light in a particular region (NE) above the solar limb (values up to 7%). This is believed to come from spurious reflections within the telescope. The full Stokes vector of the background light was therefore subtracted from the total measured Stokes vector.

In order to account for the cross-talk from the linear polarization to the circular polarization (values up to about 18% at solstice) measurements were performed applying a linear polarization filter in different positions before the entrance window of the telescope. The cross-talk from the circular to the linear polarization was not taken into account since it was expected to be negligible.

### 3. Results

An example of the four Stokes spectral images resulting from the measurement of one prominence with the ZIMPOLII system is reported to the left in Fig. 1. In this preliminary analysis we look at the spectro-polarimetric profiles obtained integrating over the spatial region where the signal intensity is at least 50% of the maximum intensity. The profiles of Stokes  $Q$ ,  $U$  and



*Figure 1.* Left: Example of spectral images of the four Stokes parameters (obtained with the ZIMPOLII system on the 23rd May 2003). Right: Polarization profiles obtained from the same images integrating the spatial region where the intensity signal is larger than half the maximum. Shown are Stokes  $Q$ ,  $U$  and  $V$  divided by the maximum of the intensity profile  $I_{\max}$ . The scaled intensity profile is shown by a hatched line.

$V$  divided by  $I_{\max}$  (the maximum of the intensity profile) are shown in the right panel of Fig. 1. Two resolved multiplet components can be observed: a strong blue component at  $5875.6 \text{ \AA}$  and a faint red component at  $5875.97 \text{ \AA}$ . To analyze the behavior of the two components we average the value of the relative polarization in the intervals  $5875.5\text{-}5875.7 \text{ \AA}$  respectively  $5875.9\text{-}5876.0 \text{ \AA}$ . It is found that usually  $Q/I$  is about a factor of two larger in the faint component than in the strong component, as can be observed in the left plot of Fig. 2. In the right panel we show indeed for the strong component the Hanle diagram, where the total linear polarization versus the rotation angle  $\alpha = \arctan(U/Q)$  is plotted. The results obtained with the two techniques for different prominences are similar.

#### 4. Conclusions

The instrumentation at IRSOL and the two techniques used allowed precise measurements of the profiles of all four Stokes components in the HeI-D<sub>3</sub> emission line of 35 prominences.  $Q/I$  was found to be always positive with values up to 7% in the faint red multiplet component and up to 3% in the blue component. The absolute values of  $U/I$  and  $V/I$  were generally below 2% and 0.5% respectively.

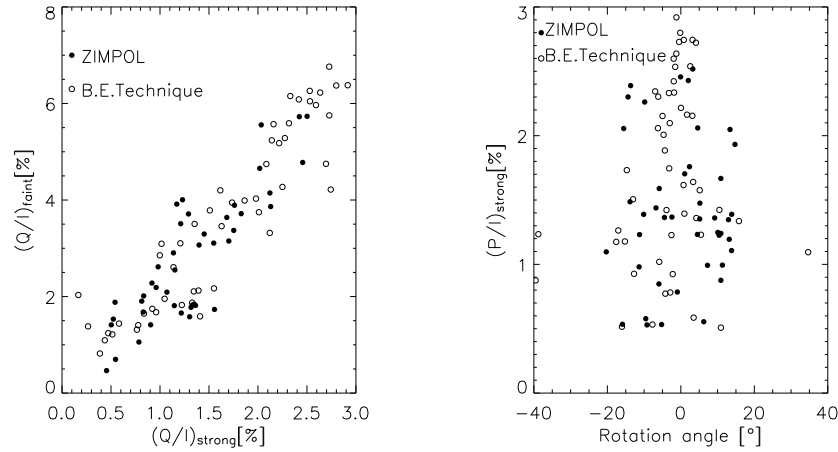


Figure 2. Left: Scatter plot representing Stokes  $Q/I$  measured in the faint red component of the  $D_3$  multiplet versus Stokes  $Q/I$  measured in the strong blue component. Right: Hanle diagram showing the total linear polarization versus the rotation angle  $\alpha = \arctan(U/Q)$  for the strong blue component.

### Acknowledgements

We thank Prof. Jan Stenflo and his group who allow us to use the ZIMPOLII system. We are grateful for the financial support that has been provided by the canton of Ticino, the city of Locarno, and ETH Zurich. We appreciated the helpful and interesting discussions that we had with Prof. Jan Stenflo, Prof. Javier Trujillo Bueno and Laura Merenda.

### References

- Athay, R.G., Querfeld, C.W., Smartt, R.N., Landi Degl'Innocenti, E., and Bommier, V.: 1983, *Solar Phys.* **89**, 3.
- Bianda, M., Solanki, S.K., and Stenflo J.O.: 1998, *Astron. Astrophys.* **331**, 760.
- Gandorfer, A.: 1999, *Opt. Eng.* **38**, 1402.
- Gandorfer, A. and Povel, H.P.: 1997, *Astron. Astrophys.* **328**, 381.
- Leroy, J.L., Bommier, V., and Sahal-Br  chot, S.: 1984, *Astron. Astrophys.* **131**, 33.
- Paletou, F., L  pez Ariste, A., Bommier, V., and Semel, M.: 2001, *Astron. Astrophys.* **375**, L39.
- Povel, H.P.: 1995, *Opt. Eng.* **34**, 1870.
- Sanchez Almeida, J., Mart  nez Pillet, V., and Wittmann A.D.: 1991, *Solar Phys.* **134**, 1.
- Semel, M., Donati, J.-F., and Rees, D.E.: 1993, *Astron. Astrophys.* **278**, 231.
- Stenflo, J.O., Keller, C.U., and Povel, H.P.: 1992, LEST Foundation Technical Report No. **54**, Univ.Oslo.
- Wiehr, E. and Bianda, M.: 2003, *Astron. Astrophys.* **404**, L25.